CLAIMS

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1) Autoprotected optical communication ring network, including a first and a second optical carrier (2, 3) having opposite transmission directions and a plurality of optically reconfigurable nodes (20a-20f) optically connected along the first and the second optical carrier (2, 3) and adapted to communicate in pairs by means of respective links susceptible of failure, the ring network having a normal operative condition in which the nodes of each pair are optically configured so as to exchange optical signals on a respective working arc path at a respective first wavelength (λ_x) on the first carrier (2) and at a respective second wavelength (λ_y) different from said first wavelength (λ_x) on the second carrier (3), said respective working path having a complementary arc path defining a respective protection arc path in which the first wavelength (λ_x) on the first carrier (2) and the second wavelength (λ_y) on the second carrier (3) can be used for further links and the first wavelength (λ_x) on the second carrier (3) and the second wavelength (λ_y) on the first carrier (2) are reserved for protection, characterized in that the ring network has a failure operative condition in which the nodes terminating a failured link are optically reconfigured so as to exchange optical signals on the respective protection arc path at the respective second wavelength (λ_y) on the first carrier (2) and at the respective first wavelength (λ_x) on the second carrier (3).

2) Ring network according to claim 1, wherein each of said plurality of reconfigurable nodes (20a-20f) is adapted to manage a predetermined subset of wavelengths within a set of transmission wavelengths (λ_1, λ_2, .., λ_N) and includes a first and a second optical add/drop multiplexer (4, 5) serially connected to said first and, respectively, second carrier (2, 3) to feed/extract said subset of wavelengths to/from said first and, respectively, second carrier (2, 3), and to pass-through the remaining wavelengths of the set of transmission wavelengths (λ_1, λ_2, .., λ_N).

3) Ring network according to claim 1 or 2, wherein said plurality of reconfigurable nodes (20a-20f) includes at least a signal input (IN_1, IN_2), at least a signal output (OUT_1, OUT_2) and a reconfigurable optical switch unit (15; 15'; 15"; 115'; 115"; 215) selectively coupling said at least an signal input (IN_1, IN_2) and said at least a signal output (OUT_1, OUT_2) to said first and second carriers (2, 3).

4) Ring network according to claim 3, wherein said at least a signal input (IN_1, IN_2) is optically coupled to a respective optical transmitter (Tx_1) and said at least a signal output (OUT_1, OUT_2) is optically coupled to a respective optical receiver (Rx_1).

5) Ring network according to claim 3 or 4, wherein each of said plurality of reconfigurable nodes (20a-20f) includes information insertion devices (TxTs) selectively optically connectable to said at least a signal input (IN_1, IN_2) and adapted to insert signalling information into the optical signals and information extraction devices (RxTs) selectively optically connectable to said at least a signal output (OUT_1, OUT_2) and adapted to extract signalling information from the optical signals.

6) Ring network according to claim 5, wherein said information insertion devices (TxTs) and said information extraction devices (RxTs) include optical transponders optically coupling said optical switch unit (15; 15'; 15"; 115'; 115"; 215) to said first and second carrier (2, 3) and adapted to change the signals wavelengths.

7) Ring network according to claim 3, wherein at least one of said reconfigurable nodes (20a-20f) includes at least a first signal spitter (222-225) adapted to receive a signal from either the first or the second carrier (2, 3) and to split said signal into a first and a second fraction which are sent towards a respective signal output (OUT_1, OUT_2) and towards the same carrier (2, 3), respectively.

8) Ring network according to claim 3, wherein at least one of said reconfigurable nodes includes at least a second signal spitter (221, 226) optically coupled to a respective signal input (IN_1, IN_2) and adapted to spit a signal coming from the respective signal input (IN_1, IN_2) into a first and a second fraction which are sent towards the first carrier (2) and the second carrier (3), respectively.

9) Ring network according to claims 3, wherein said optical switch unit (215) includes at least a first switch (231, 233, 235, 236) having a first input optically coupled to a respective signal input (IN_1, IN_2), a second input coupled to either the first or the second carrier (2, 3) and an output coupled the same carrier (2, 3).

10) Ring network according to claim 8, wherein said optical switch unit (215) includes

at least a second switch (232, 234) ~~having a first input~~ coupled to the first carrier (2), a second input ~~coupled the~~ second carrier (3), and an output optically coupled to a respect~~ive signal~~ output (OUT_1, OUT_2).

~~11) Optical transmission~~ system, including a ~~first and a second~~ ring network according to claim 3, wherein a first reconfigurable node (D) of the first ring network has a signal input (IN_1, IN_2) which is optically coupled to a signal output (OUT_1, OUT_2) of a second reconfigurable node (D') of the second ring network.

12) Optical transmission system according to claim 11, wherein the second reconfigurable node (D') has a signal input (IN_1, IN_2) which is optically coupled to a signal output (OUT_1, OUT_2) of the first reconfigurable node (D).

13) Optical transmission system according to claim 11, wherein a third reconfigurable node (E) of the first ring network has a signal input (IN_1, IN_2) which is optically coupled to a signal output (OUT_1, OUT_2) of a fourth reconfigurable node (E') of the second ring network, and the fourth reconfigurable node (E') has a signal input (IN_1, IN_2) which is optically coupled to a signal output (OUT_1, OUT_2) of the third ~~reconfigurable node (E)~~.

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14) Method to autoprotect an optical ring network, said ring network including a first and a second optical carrier having opposite transmission directions and a plurality of nodes optically connected along the first and the second optical carrier and adapted to communicate in pairs in order to define bidirectional links, each pair including a first and a second link termination node adapted to mutually communicate at respective first and second wavelengths, the method including:

- exchanging signals between the first and the second link termination node of each pair on a respective working arc path of said ring network by using the respective first wavelength on the first carrier and the respective second wavelength on the second carrier; said respective working path having a complementary arc path defining a respective protection arc path in which the first wavelength on the first carrier and the second wavelength on the second carrier can be used for further links and the first wavelength on the second carrier and the second wavelength on the first carrier are reserved for protection;

- checking if a failure is present in the ring network producing at least a failured link; and
- optically reconfiguring, in the presence of a failure, the link terminating nodes of said at least a failured link so that they exchange signals on the respective protection arc path by using the respective first wavelength on the second carrier and the respective first wavelength on the second carrier.

15) Method according to claim 14, wherein each node of said plurality of nodes is adapted to manage a predetermined subset of wavelengths within a set of transmission wavelengths carried by the first and the second carrier, said step of exchanging including optically separating, at each node of said plurality of nodes, each wavelength of the respective subset of wavelengths from the set of transmission wavelengths.

16) Method according to claim 14, including the steps of inserting a signal into one of said nodes, splitting said signal into a first and a second fraction and sending said first fraction towards the first carrier and the second power fraction towards the second carrier.

17) Method according to claim 14, including the steps of receiving a signal in one of said nodes from either the first or the second carrier, splitting said signal into a first and a second fraction, sending the first fraction towards the same carrier and the second fraction towards a signal output of said node.

~~18)~~ Method according to claim 14, wherein the step of checking includes verifying, ~~in~~ each node of said plurality of nodes and for each wavelength of the respective set of wavelengths, if signals are received.

19) Method according to claim 14, wherein said step of checking includes verifying, in each node of said plurality of nodes and for each wavelength of the respective set of wavelengths, if signals are received degraded.

20) Method according to claim 14, wherein said step of checking includes verifying, in each node of said plurality of nodes and for each wavelength of the respective set of wavelengths~~, if signals include a failure message~~.

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21) Method according to claim 14, further including transmitting a failure message from a first link termination node of a pair to a second link termination node of the same pair if a signal transmitted from the second link termination node to the first link termination node is not received, or is received degraded, by the first link termination node.

22) Method according to claim 14, wherein said step of reconfiguring includes switching optical connections which selectively couple at least an optical transmitter and an optical receiver to said first and second carrier.

23) Method according to claim 15, wherein the step of exchanging includes feeding at each of said plurality of nodes the corresponding subset of wavelengths to said first and, respectively, second carrier.

24) Method according to claim 14, wherein the step of exchanging signals includes the following steps executed in the first link termination node of a pair:

- generating an optical signal carrying an information;
- converting the optical signal in a electrical signal;
- adding to the electrical signal further information;
- reconverting the electrical signal in an optical signal provided with a predetermined wavelength adapted for transmission; and
- feeding the optical signal at the predetermined wavelength to either the first or the second carrier;

and the following steps executed in the second link termination node of the same pair:

- receiving the optical signal at the predetermined wavelength from either the first or the second carrier;
- converting the optical signal at the predetermined wavelength in an electrical signal;
- extracting from the electrical signal the further information;
- reconverting the electrical signal in an optical signal with a wavelength adapted for reception; and
- receiving the optical signal with the wavelength adapted for reception.

~~25) Reconfigurable node for an autoprotected optical communication ring network,~~ comprising a receiving/transmitting module (6) including:

- a signal input (IN_1) for the insertion into the node of a signal including information to be transmitted in the network;
- a signal output (OUT_1) for the extraction from the node of a signal including information transmitted in the network;
- a first transmitting transponder ($TxT_1(\lambda_x)$) for optically coupling to a first carrier (2) of the network and adapted to modulate a signal at a first wavelength (λ_x);
- a second transmitting transponder ($TxT_1(\lambda_y)$) for optically coupling to the first carrier (2) and adapted to modulate a signal at a second wavelength (λ_y);
- a third transmitting transponder ($TxT_2(\lambda_x)$) for optically coupling to a second carrier (3) of the network and adapted to modulate a signal at the first wavelength (λ_x);
- a first receiving transponder ($RxT_2(\lambda_x)$) for optically coupling to the second carrier (3) and adapted to demodulate a signal having the first wavelength (λ_x);
- a second receiving transponder ($RxT_2(\lambda_y)$) for optically coupling to the first carrier (2) and adapted to demodulate a signal having the second wavelength (λ_y);
- a third receiving transponder ($RxT_1(\lambda_y)$) for optically coupling to the second carrier (3) and adapted to demodulate a signal having the second wavelength (λ_y);
- reconfigurable optical connections (22-25; 31-38; 41-48; 131-136; 141-146; 231-236) to selectively connect:
    - the signal input (IN_1) either to the first transmitting transponder ($TxT_1(\lambda_x)$) or to the third transmitting transponder ($TxT_2(\lambda_x)$);
    - the first receiving transponder ($RxT_2(\lambda_x)$) to the third transmitting transponder ($TxT_2(\lambda_x)$);
    - the second receiving transponder ($RxT_2(\lambda_y)$) to the signal output (OUT_1); and
    - the third receiving transponder ($RxT_1(\lambda_y)$) either to the signal output (OUT_1) or to the second transmitting transponder ($TxT_1(\lambda_y)$).

26) Reconfigurable node ~~according to claim 25,~~ wherein ~~the receiving/transmitting~~

~~module (6) further includes:~~

- a further signal input (IN_2) for the insertion ~~into the node of a signal including~~ information to be transmitted in the network;
- a further signal output (OUT_2) for the extraction from the node of a signal including information transmitted in the network;
- a fourth transmitting transponder ($TxT_2(\lambda_y)$) optically coupled to the second carrier (3) and adapted to modulate a signal at the second wavelength (λ_y); and
- a fourth receiving transponder ($RxT_1(\lambda_x)$) optically coupled to the first carrier (2) and adapted to demodulate a signal having the first wavelength (λ_x);

said reconfigurable optical connections (22-25; 31-38; 41-48; 131-136; 141-146; 231-236) selectively connecting:

- the first receiving transponder ($RxT_1(\lambda_x)$) either to the third transmitting transponder ($TxT_2(\lambda_x)$) or to the further signal output (OUT_2);
- the fourth receiving transponder ($RxT_1(\lambda_x)$) to the further signal output (OUT_2); and
- the further signal input (IN_2) either to the second transmitting transponder ($TxT_1(\lambda_y)$) or to the fourth transmitting transponder ($TxT_2(\lambda_y)$).

27) Reconfigurable node according to claim 25 or 26, characterized in that it is adapted to manage a predetermined set of wavelengths within a set of transmission wavelengths ($\lambda_1, \lambda_2, .., \lambda_N$) and in that it includes a first and a second optical add/drop multiplexer (4, 5) optically coupling the receiving/transmitting module (6) to said first and, respectively, second carrier (2, 3) to feed/extract said subset of wavelengths to/from said first and, respectively, second carrier (2, 3), and to pass-through the remaining wavelengths of the set of transmission wavelengths ($\lambda_1, \lambda_2, .., \lambda_N$).

28) Reconfigurable node according to claim 25 or 26, further including at least a first optical power splitter (221) for splitting signals coming from said at least a signal input (IN_1) and at least a second optical power splitter (222-225) for splitting signals coming from a respective one of said receiving transponders (RxTs).

29) Reconfigurable node according ~~to claim 25 or 26,~~ wherein the ~~reconfigurable~~

~~optical connections (22-25) include 2x2 switches.~~

30) Reconfigurable node according to claim 25 or 26, wherein the reconfigurable optical connections (31-38; 41-48; 131-136; 141-146; 231-236) include 1x2 and/or 2x1 switches.

31) Reconfigurable node according to claim 25 or 26, wherein the reconfigurable optical connections (22-25; 31-38; 41-48; 131-136; 141-146; 231-236) include discrete switching components.

32) Reconfigurable node according to claim 25 or 26, wherein the reconfigurable optical connections (22-25; 31-38; 41-48; 131-136; 141-146; 231-236) include an integrated switching matrix.

33) Reconfigurable node according to claim 25 or 26, wherein the reconfigurable optical connections (22-25; 31-38; 41-48; 131-136; 141-146; 231-236) include optical switching components selectable in the group including:

- opto-mechanical switches;
- thermo-optical switches;
- magneto-optical switches;
- liquid crystal switches;
- semiconductor switches;
- electro-optical switches;
- micro-mechanical switches; and
- lithium niobate integrated circuit switches.

34) Reconfigurable node according to claim 25 or 26, characterized in that it includes a control processing unit (16) operatively connected to said receiving transponders (RxTs) and said transmitting transponders (TxTs).

35) Reconfigurable node according to claim 25 or 26, characterized in that it includes at least a further receiving/transmitting module which has substantially the same structure of said receiving/transmitting module (6) and is adapted to operate with a different pair of wavelengths with respect to said receiving/transmitting module (6).